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THE RÔLE OF EPITHELIUM IN EXPERIMENTAL IMMUNIZATION[1]

SOME twelve years ago I became impressed with the idea that the surface epithelium of the body, including the epidermis and the succulent coverings of the respiratory and alimentary canals, must have important functions in mediating between foreign material brought in contact with it and the internal tissues which it covers.[2]

From either a physiological or pathological point of view the surface epithelium forms the "first line of defense" of the body.

Our modicum of knowledge respecting the protective attributes of this covering embraces two certainties—that it is a mechanical barrier intervened to the passage of foreign material, especially when particulate; and that, when part of a mucous membrane, it is a metabolizing organ capable of chemically changing foreign substances in contact with it.

And yet, in the vast majority of experiments designed to elucidate the reactions of the living tissues toward such materials, these are introduced by traumatic methods avoiding the first line of defense.

An animal might conceivably live long without ever suffering a lesion through which foreign matter might be absorbed, but no mammal has ever escaped the necessity of swallowing or inhaling extraneous substances, including proteins which act as antigens when introduced as such within the body.

The following observations are concerned in no way with reactions of the alimentary canal but only with the mucous membrane of the nasal chambers.

The fact is sufficiently extraordinary that, in the healthy subject, the epithelium of the lungs and bronchi is free from microorganisms, untold numbers of which daily enter the nose. What has become of them? What chemical changes have attended their destruction? What tissue reactions have answered the absorption of such foreign proteins or their digested products?

It seems plausible that "natural immunity" might find its extraneous stimulus in such conditions of antigenic absorption.

For three years, with the invaluable cooperation of my colleague, Dr. Cuthbert Powell, I sought to outline experimentally the immunological attributes of the

[1] Chairman's address, Medical Section, Southwestern Division, of the American Association for the Advancement of Science, Boulder, Colorado, June 9, 1925.

[2] Sewall, H., *Archives of Int. Med.*, 1914, XIII, 856.

epithelium covering the mucous membrane of the nose.[3, 4]

It seems advisable to briefly review our results at the present time in the light of important researches more recently conducted by somewhat similar methods in France.

The guinea pig was the animal best adapted to our study and normal horse serum offered a complex of antigens most convenient for use. The guinea pig is unrivalled in constitutional aptitude for quick and clear-cut immunologic reactions; the length of its nasal canals reaches about five centimeters and they present an extraordinary expanse of mucous membrane. Normal horse serum, in convenient holders, is available in unlimited quantity.

The method of experimentation was divided into two correlated stages. There was first a preparatory treatment consisting of a series of instillations of undiluted horse serum into the anterior nares in definite amounts, ranging from 0.02 cc to 0.2 cc at each instillation, and at definite intervals varying from a few hours to twenty-four days between the instillations. The serum was administered from an all-glass syringe capped by a needle with blunted end. The guinea pig was held supine upon a table, its head being clasped gently with the left hand.

The desired number of droplets of serum was allowed to fall upon one or the other naris, care being taken, usually, to alternate the right and left nares at succeeding instillations. It is important, in seeking the immunologic effects to be described, that the instillation be carried out slowly so that each droplet disappear before the next is allowed to fall in the nostril; thus from three to five minutes are consumed in the instillation of 0.2 cc serum. It is also to be advised that the long axis of the animal's head be held nearly parallel with the plane of the table.

It has been proved beyond doubt that a series of instillations of serum as described, while innocuous and provoking no change in the behavior of the normal guinea pig, nevertheless causes a revolution in the internal economy of the animal which alters its immunological state.

The test and proof of such a constitutional change is to be found in the application of a chemical reagent, horse serum, by intravenous injection. It has long been known that when a guinea pig is given a small subcutaneous injection of serum it undergoes internal changes the effect of which can be demonstrated after eight, and which reach approximately full development in thirty days after the inoculation. If such an animal be given an intravenous injection of, say 0.2 cc to 0.4 cc serum sixteen days after the subcutaneous injection it almost invariably dies in convulsions within a few minutes.

The preliminary subcutaneous injection of *antigen*, horse serum, working through an *incubation period* of eight days or more, has *sensitized* the guinea pig to the proteins in horse serum so that the subsequent intravenous injection is *toxic* and the animal dies in *anaphylactic shock*.

We will suppose that a guinea pig has received a series of spaced instillations of horse serum. Sixteen days after the instillation the animal is given intravenously an injection of approximately 0.3 cc serum.[5]

Two radically different results are obtained, the nature of which may usually be predicted from the experimental conditions which will be detailed later: (1) Within a few seconds of completing the injection the pig breathes deeply, manifests more or less vigorous, fairly localized spasms which pass off within a few minutes, when the animal completely recovers. Every grade in the extent and intensity of these disturbances may be witnessed, resulting in an extreme case in powerful generalized convulsions which may throw the pig, when released, into somersaults and lead to death from asphyxia in three minutes. Opening the thorax the pallid lungs protrude from the chest, respiratory motion is checked, but the heart still feebly beats. This is the classic and familiar picture of anaphylactic death. The guinea pig had been strongly sensitized by the intranasal absorption of serum and the "toxic" injection of the same antigen finds in the circulation a sufficient quantity of allergic or anaphylactic antibodies to develop a quickly fatal poison. (2) But another and apparently completely negative result may follow the toxic injection in a second guinea pig which had received a preliminary sensitizing course of instillation similar to the first. Now the animal lies undisturbed during the toxic injection, except, possibly, for a more restrained and shallow breathing. It would seem that the preliminary nasal instillations of serum had failed to be absorbed.

Further experimentation proves such a conclusion to be premature. From a group of guinea pigs dealt with as above, select two which had survived the toxic injection, one after slight and the other after more severe convulsions, and also two which had withstood the same treatment without disturbance.

Twenty-four days after the first intravenous injection subject all four pigs to a second toxic injection of the same amount of serum as before. Within this period, rising three weeks, the animals which had re-

[3] Sewall, H., and Powell, C., *Arch. of Int. Med.*, 1915, XVI, 605.

[4] Sewall, H., and Powell, C., *Jour. Exp. Med.*, 1916, XXIV, 69.

[5] *Ibid., Arch. of Int. Med.*, 1915, XVI, 605.

acted negatively to the first toxic injection must, if they were normal, have been powerfully sensitized by it and should have promptly died under the second toxic dose. But we would have obtained different results, somewhat as follows: The guinea pig which under the first toxic injection had shown severe convulsions would probably die under the second; the pig which had shown moderate disturbance with the first would probably survive the second after more or less severe spasms, while the two animals which had reacted negatively to the first intravenous injection would probably survive the second with or without convulsive movements.

The repetition of toxic injections could probably be continued indefinitely, but we have not carried them beyond six. For reasons that will be mentioned, a guinea pig may succumb to the third or fourth injection when it might have been supposed to be on the road to complete immunity.[6]

It might be objected that the results described above illustrate nothing more than the condition of tolerance which can be produced in a guinea pig which has received a close succession of massive intraperitoneal injections of horse serum. As is well known, however, such tolerance, while it may be maintained by relatively frequent repetition of the toxic injections, tends always to diminish and hypersensitiveness to redevelop when the resting period between the injections is prolonged. Quite the reverse is found to be the case in guinea pigs which have received their preliminary sensitization through nasal instillations; such have armed the animal fairly completely against the first toxic injection of serum. Here we find that the ability of the animal to withstand the intravenous injection of antigen tends to progressively improve with lapse of time. For example: of two guinea pigs prepared by the same course of nasal instillations both easily survived the intravenous injection, respectively, of 0.31 cc and 0.38 cc of serum given sixteen days after the last instillation.

Fourteen days later the former pig received a second toxic injection, increased to 0.38 cc, and died; the latter animal was kept for sixty-eight days before receiving its second toxic injection, increased to 0.5 cc, and easily survived; one hundred and twenty-two days later it tolerated a third injection, increased to 0.75 cc. Again, three young guinea pigs were prepared by six instillations of 0.19 cc serum at intervals of fourteen days. All received the first toxic injection of 0.38 cc sixteen days after the last instillation. Pigs 1 and 3 were not affected; pig 2 responded with moderate shock. Twenty-four days later the toxic injection was repeated. Now pig 1 suffered moderate shock, 2, very severe shock and 3 was but little affected. After a resting period of seventy-five days a third toxic injection was given without affecting either animal. Thirty-six days later pig 1 received a fourth toxic injection increased to 1.1 cc and survived after nearly fatal convulsions. Pigs 2 and 3 were allowed to rest for one hundred and one days after their third injection, when they were given a fourth increased to 1.13 cc serum, and both withstood it with little or no response.[7]

In a group of five pigs sensitized by six massive intraperitoneal injections of serum within ten days, although two of them withstood a series of seven toxic injections, it was obvious that lengthening the periods between the injections, as well as increasing the amount of serum, tended to a fatal result.[8]

I will now briefly survey the factors which appear to determine the nature of the immunologic reactions in animals whose sensitization has been induced by spaced nasal instillations of horse serum.

The following variables obviously offered themselves for study: (1) the number of separate instillations of serum; (2) the time interval between them; (3) the quantity of serum used with each instillation. Subsequently, it was important to note: (1) the number of toxic intravenous injections; (2) the amount of serum employed in each; (3) the intervals elapsing between them; (4) the biologic reactions resulting.

We performed a large number of experiments to determine the relative effects of varying the separate instillations from a total of two to twelve in number, and of increasing the resting intervals between the instillations from fifteen hours to twenty-four days.[9]

We conclude from our observations that the optimum number of nasal instillations of horse serum preparatory to immunization in guinea pigs is four or six, the serum being introduced into alternate nostrils at successive sittings. Probably the most favorable interval between the instillations is one of two to four days. Certainly a period of one day or less or as long as twenty-four days is relatively ill adapted for immunization.

Up to this point we had failed to determine the experimental condition underlying the development, through toxic injection, of anaphylactic shock or death, on the one hand, or prolonged immunity on the other. A more satisfactory outcome attended study of the third variable mentioned above, namely, the *quantity* of serum dropped into the nose or later injected into the vein.

Special consideration was given to this subject in a former article from which is quoted:

[6] *Ibid.*

[7] *Ibid.*

[8] *Ibid., Jour. Exp. Med.,* 1916, XXIV, 69.

[9] *Ibid., Arch. of Int. Med.,* 1915, XVI, 605.

Of nine guinea pigs receiving a course of instillations of 0.2 cc, only one survived the first toxic injection and in this case the amount of serum given by the vein had been reduced to 0.25 cc. From the reaction manifested by the animal it is probable that it would have succumbed to the nasal injection of 0.38 cc. Of twenty guinea pigs receiving a series of instillations of 0.04 cc or less only one succumbed to the first intravenous injection of 0.38 cc horse serum given sixteen days after the last instillation. Twelve of the twenty animals withstood a second intravenous injection fourteen or more days after the first.[10]

It is to be expected that, other things equal, the area of contact between serum and mucous membrane must determine the amount of absorption and consequent reactions. When the serum is dropped slowly, three to five minutes being consumed in administering 0.2 cc, and the head of the animal is extended with its axis parallel to the table, the serum must gravitate among the convolutions of the nose. As the head is inclined toward the vertical and the dose of serum is given quickly, within thirty seconds, the area of mucous membrane covered as well as the duration of contact is probably reduced. By manipulation of these factors it is possible to evoke a stronger sensitizing effect from a series of instillations of 0.04 cc serum administered according to the first method than from a dosage five times as great by the second.[11]

We thus arrived through experimental means to a wholly rational explanation of the conditions determining the operation of the antigen instilled. The effects are, roughly, proportional to the amount of serum actually absorbed by the mucous membrane. Nor is the interval between the successive instillations a matter of indifference. A period of forty-eight hours seems to be the shortest in which the tissues can react to a given instillation so that the succeeding one may add a protective rather than an allergic effect.

The prophylactic virtues of the two days' interval of rest would seem from clinical experience to stamp also the evolution of bacterial infection. Thus, in a valuable paper,[12] L. Heidenhain urges every operator who suffers an accidental prick with an infected instrument to instantly put the member at rest for two days; an injury to the hand demands that the arm be carried in a sling for that period. In his experience no instance of blood poisoning has followed such treatment, while septicemia has been frequent without it. I have elsewhere pointed out the expediency of limiting tubercular patients who easily develop fever with exertion to exercise on alternate days.[13]

[10] *Ibid., Jour. Exp. Med.,* 1916, XXIV.

[11] *Ibid.*

[12] Heidenhain, L., *Münch. med. Woch.,* 1915, LXXII, 1482.

[13] Sewall, H., *Amer. Rev. Tuberculosis,* 1921, V, 236.

There is an objective sign of allergic reaction which may appear in the course of nasal instillation and which, under known conditions, becomes invariable. This reaction is best brought out by intranasal dosages of 0.2 cc of serum.

. . . Pigs which, after daily treatment for three or four times, are allowed to rest for sixteen days before the next instillation, or pigs at about the fourth treatment in a series with twenty-four days' intervals . . . are apt to manifest characteristic symptoms of sensitization. Two or three minutes after beginning the instillation more or less active movements of intestinal peristalsis are seen. If the pig is a noticeably pregnant female twitching of the lower abdominal wall is obvious, and if pregnancy is far advanced, within a few days of term, there are very active fetal movements which seem, when felt by the hand, to be active fetal contractions.

I have not been able to assure myself that these movements are not imparted to the fetus by vigorous uterine contractions. . . . *During the fetal turmoil the mother remains passive.* Succeeding the onset of intestinal peristalsis the respiratory movements are apt to become deeper, and in about one fifth or more of the cases clicking rales are felt in the throat, then rales are heard in the nose and extend to the bronchial tubes, the animal coughs, becomes dyspneic and is involved in the throes of a bronchial asthma which is almost identical in its symptoms with an asthmatic attack in the human subject. The respiratory urgency gradually passes off in about half an hour, but the animal may still be disturbed after several hours.

We can state definitely that the more marked are these signs of *quasi*-local sensitization the more likely is the animal to succumb to the toxic intravenous injection. In pigs which have been previously highly sensitized by a single subcutaneous injection, serum dropped into the nose is apt to cause, after a small number of treatments, immediate frantic signs of distress to be succeeded in a few minutes by an urgent asthma.[14, 15]

Blood serum, of course, contains a number of different antigens; it was therefore gratifying to receive a personal communication from Dr. V. C. Vaughan that he had confirmed the above observations, using pure edestin or egg-white as antigens.

It is worth noting that when a sensitized pig is made to inhale serum in a nebulized form, driven into a pasteboard funnel encompassing the face of the animal, severe asthma is likewise produced; but in this case, in our experience, no rales were heard; the asthma was *dry*.[16]

In pondering the reasons for the extraordinary biological difference betwen the extremes of our anaphylactic and immune guinea pigs the most reasonable explanation seems to be found on the assumption of

[14] *Ibid., Arch. of Int. Med.,* 1915, XVI, 605.

[15] Sewall, H., *Jour. Lab. and Clin. Med.,* 1817, II, 874.

[16] *Ibid., Arch. of Int. Med.,* 1914, XIII, 856.

two antagonistic antibodies generated in response to serum instillation. One of these is an allergic or sensitizing antibody; the other is an inhibitory resistant or, as we prefer to call it, an immune antibody.

If this supposition be correct it ought to be possible to determine the specific characters of a circulating antibody by bleeding an experimentally prepared animal and injecting its serum into the peritoneal cavity of a normal guinea pig.

It is well known that when the serum is thus transferred from an animal "immunized" in the ordinary way, by subcutaneous or intraperitoneal injection of the serum, the recipient normal animal becomes "passively hypersensitive," so that when it is given an intravenous injection of serum, after a period of one to three days, it usually dies in anaphylactic shock.

We performed, with the invaluable aid of our colleague, Dr. W. C. Mitchell, a few experiments in this field and the results were so remarkable that an excerpt from them is given here.[17] Two guinea pigs were prepared by the instillation of horse serum six times on alternate days. Pig A received 0.04 cc serum at each dose. According to hypothesis this animal should have developed, especially, protective or immunizing antibodies during the course of incubation. Pig B received the same number of instillations but of five times the quantity as A, namely, 0.2 cc. Twenty-one days after the last instillation both pigs were bled and their serums were injected intraperitoneally into six normal young guinea pigs.

Forty-eight hours later each of the latter was given an intravenous injection of 0.25 cc horse serum. Normal pigs 1 and 2 had received serum from donor A; pigs 3 and 4 from donor B. All survived the toxic injection after more or less shock. When the toxic injection was repeated in fifteen days all four recipient pigs died.

But normal pigs 5 and 6 were prepared differently. In their case the serums from the donors A and B were mixed in varied proportions and incubated for some minutes at body temperature. The total amount of serum injected into 5 and 6 was less than that used in either 3 or 4.

Pigs 5 and 6 to which had been transferred the mixed "immune" and "sensitized" serums, both withstood, not only the first toxic injection after forty-eight hours but also a series of other toxic injections following at intervals of 15, 14, 17 and 59 days. The quantity of serum in the last two injections was raised to 0.38 cc, but the tolerance was nearly complete, though profound shock had been excited earlier in the series. It should not be overlooked that the pigs which furnished the serum in the above experiments had been prepared only by the nasal instillation of serum and had lacked in their treatment those aids to the multiplication of antibodies that must come from the enormously greater doses of serum employed in our usual series of toxic injections.

The procedures described above were repeated on groups of guinea pigs as donors of serum which had, on the one hand, been strongly protected by intravenous injections after a preliminary course of instillations, and, on the other, of pigs which had been "immunized" by a succession of massive intraperitoneal injections of serum without previous nasal instillations.

The detailed results must be found in the original paper. Suffice it to say that in these experiments the transfer of serum from the first class of immune donors, those which had received preliminary nasal instillations, protected normal pigs against a succession of toxic injections; while the transferred serum from the second class of (non-instilled) immunes caused death of the recipient pigs under the first toxic injection. Mixtures of the two donated serums obviously protected the recipients.

Apparently the only work that bears definitely upon our conclusions is that of Gurd.[18] His researches were carried on independently and, apparently, somewhat antecedent to our own.

Gurd's experiments consisted in the transfer to young normal guinea pigs of the serum from rabbits which had received injections of sheep's blood serum and were kept for a sufficient time for development in the rabbit of antibodies against sheep's serum.

A normal guinea pig thus inoculated should within twenty-four hours become passively sensitized toward sheep serum and should show anaphylactic reaction when given an intravenous injection of the latter. Gurd found, however, that according to the amount of immune serum transferred and the amount of antigen injected into the guinea pig the response of the latter was positive or negative. He assumes from his results the "presence in the circulating blood of immune animals of bodies which are potent to induce the hypersensitive state when introduced into normal animals and also of bodies which, if injected in sufficient quantities, are able to render normal animals immune."

He writes further that when a guinea pig is made hypersensitive by the inoculation of foreign serum, "subsequent inoculation in sublethal doses results in the stimulation of the production of a second order of ferments whose activity is directed more particularly toward the more complete cleavage of the toxic split product."[19] One familiar with the literature will

[17] Sewall, H., Mitchell, W. C., and Powell, C., *Jour. Amer. Med. Assoc.*, 1916, LXVII, 95.

[18] Gurd, F. B., *Jour. Med. Res.*, 1914, XXXI, 205.

[19] Vaughan, V. C., "Protein Split Products," 1913, Lea & Febiger.

recognize that the "toxic split product" is a result of the interaction of the "first order of antibodies" which had been developed under stimulus of the sensitizing antigen, commonly known as the "anaphylactic antibody," and the protein introduced with the toxic injection.

Gurd's experiments seem to me to furnish insufficient ground for his sweeping conclusions, nevertheless he has recently made them the basis of a most stimulating and suggestive monograph.[20]

The deductions drawn from our own work confirm, in the main, the conclusions envisaged by Gurd, but I believe that our method for the primary production of antibodies, by the instillation of serum into the nose, possesses specific advantages for increasing either the numerator or denominator of the ratio of the sensitizing or anaphylactic to the immune or protective antibody.

It is the great merit of Gurd to have conceived the existence of a "second order of antibodies" having protective powers. But his assumption is gratuitous that this is a *ferment* and that its function is that of a lysin of the toxic split product, or that, if so, it is destroyed in the process.

We seem to have demonstrated, also, that, contrary to Gurd, this second order of antibodies is generated preferably by minute doses of antigen and that its formation begins with the very first introduction thereof.

There is little doubt that the method of choice in attempts to determine the special properties of the respiratory epithelium as a portal for the introduction of foreign protein is to apply the antigen, as we did, in a non-living liquid form.

For many years the opportunity has been denied us to test our conclusions in the field of bacteriology.

Fortunately Besredka, at the Pasteur Institute, has taken up this phase of the subject with the most definite results confirming the specific immunological relations both of the respiratory and alimentary epithelium.

More than five years after our work was published Besredka studied the reactions to horse serum introduced into the larnyx or directly into the trachea of the rabbit and guinea pig.[21] His conclusions as to the immunological advantages of this method, dependent on absorption through the epithelium of the middle respiratory tract, were so favorable that he strongly advises this avenue of treatment in human serotherapy. He also studied on rabbits the effect of introducing cultures of killed tubercle bacilli into the trachea.[22] Enormous doses could be administered without sensible harm because of the filter-like protection offered by the intact epithelium. But the bacilli were evidently at least digested *in situ* and the products absorbed, for the treatment gave rise to a much more abundant and lasting formation of antibodies than could be obtained by any other mode of inoculation. He found that the intestinal epithelium has specific relations with the activity of certain microorganisms.[23]

The germs of dysentery, for example, inoculated into rabbits by whatever method, never cause septicemia but they are always eliminated by the intestine, with local lesions.

He dwells also on the specific relations of the dermal epithelium with the virus of smallpox. In order to vaccinate an animal the skin itself must be inoculated. Vaccine virus introduced into the body without coming in contact with the skin does not vaccinate the animal, for this responds to subsequent inoculation of the skin.[24]

Sanarelli prepared powders containing killed cultures of the bacilli of typhoid, cholera or dysentery.[25] He insufflated the dried powders into the nares of rabbits. Immunity to the respective living germs was aroused by this method, as was evidenced both by the production of a high agglutination titer in the blood and by the resistance offered by the animals to intravenous inoculation with lethal doses of virulent bacilli.

This résumé by no means exhausts the French literature of the past few years confirming the postulate of specific local and general immunities set up by absorption of antigens through surface epithelium.

Summary and Conclusions

When a small amount of blood serum is dropped into the nose of a guinea pig the serum is absorbed by the mucous membrane and, after a definite period of incubation, the animal can be shown to have become profoundly changed.

Depending upon the number of instillations, the interval between them and, especially, the quantity of serum instilled, the animal becomes either highly hypersensitive or strongly resistant to a toxic injection given by the vein. This resistance withstands a considerable series of increasing toxic injections and is strengthened with lapse of time,—contrary to the state of tolerance produced by traumatic methods.

[20] Gurd, F. B., "Infection, Immunity and Inflammation," 1925, C. V. Mosby Co.

[21] Besredka, A., *Ann. de l'Inst. Pasteur*, 1920, XXXIV, 51.

[22] Besredka, A., *Ann. de l'Inst. Pasteur*, 1920, XXXIV, 361.

[23] Besredka, A., *Ann. de l'Inst. Pasteur*, 1919, XXXIII, 301.

[24] Besredka, A., *Paris Medical*, 1922, Dec. 2, p. 496.

[25] Sanarelli, G., Comptes Rendus de la Société de Biol., Dec. 19, 1924, p. 1302.

It is inferred that the absorption of foreign protein by the nose causes the formation of two different antibodies. One of these is *allergic* and excites to anaphylaxis; the other is *protective* and leads to true immuuity. The relative amount of either antibody can be regulated by modifying the amount of serum instilled.

Added to a state of general allergy it is easy to produce, in the guinea pig, a special sensitization of the respiratory apparatus which leads, under appropriate stimulation, to attacks resembling those of bronchial asthma in man.

No conclusion can be drawn at present concerning the nature or mode of action of the protective or immunizing antibody; but the indications are that its relations to the circulation and to tissue fixation resemble those which have been developed by other investigators in regard to the anaphylactic antibody.

Evidence has been submitted that the living epithelium mediates between foreign protein and the organism in a way to favor specifically the elaboration of true immunity.

HENRY SEWALL

DENVER, COLORADO

SUPERFICIAL FACTORS IN EARTHQUAKES

IN considering the earthquakes in New England and eastern Quebec of this last winter, especially the quakes of January 7 and February 28, attention is called to a factor which has been too much neglected. Several writers have written on this subject of the superficial factors, such as barometric pressures, diurnal hours of high and low barometric pressures or the "so-called" tropical hours, the tides and rainfall. The earthquake of February 28 is particularly interesting in that two of these factors, barometric pressure and deficiency of rainfall, appear to have played an important part. Before going into details of this quake a few geological observations must be made.

During the ice advances of the Glacial period, the land of New England and adjacent territory was depressed considerably below its present stand by the tremendous weight of the great glaciers, which had an average thickness of about 3,000 feet. The land was more depressed in the region of Maine, New Hampshire and Vermont and southern Canada than in southern New England, on account of the greater thickness of the ice in the more northern region. In fact, in southern New England the ice pressure is supposed to have uplifted the land near the terminal moraines instead of depressing it, in the way that a ridge is produced around your boot when stepping in soft mud. Thus Long Island, Block Island and the Cape Cod region were higher than now at the close of the Glacial period. In the region about Montreal the land was depressed about 600 feet below its present stand. On the Maine coast around Penobscot Bay it was depressed about 300 feet. Since the ice left New England about 30,000 years ago the more northern part has been uplifted and the southern part has been depressed. There has been a kind of tilt, the northern part going up and the southern part going down. The northern part has risen much more than the southern part has sunk. At the present time, therefore, there is a tendency for most of New England to rise. It was Woodworth[1] who proved these facts in 1905 in his great work on the "Ancient Water Levels of the Champlain and Hudson Valleys," and since that time other workers have proved that Woodworth was right. It is to be noted that the tendency to rise is the important point to bear in mind in considering the superficial factors discussed, in these New England and Canadian quakes.

The earthquake of January 7 was probably to the east of Cape Ann, and not many miles off shore. The fault on which this movement took place has not been located. The earthquake of February 28 appears to have had its origin near the mouth of the Saguenay River. The large amount of destruction in the villages near the mouth of the Saguenay, and the records of the distance on the Harvard and Ottawa seismographs indicate that here the greatest intensity took place. Strains that finally result in earthquakes usually go on for a long period of time, sometimes measured in many years, before the final crack comes, so in the quake under discussion the release came suddenly when conditions were just right. If New England is a rising area, anything which would tend to make its land lighter would increase the strain along the fault. A deficiency of rainfall and a low barometric pressure would be the two most effective ways of making the land lighter.

According to the data collected at the Blue Hill Observatory, we had a deficiency of about 8.1 inches of rainfall in New England during the five months previous to March 1, 1925. Reservoirs had been low, hydraulic power plants had had to shut down in many cases for lack of water, wells had gone dry and in many places there had been good cause for worry. The quake of January 7 was preceded by three months of very dry weather and immediately followed by rain and a normal rainfall for that

[1] Woodworth, J. B., "Ancient water levels of the Champlain and Hudson valleys," New York State Museum, Bull. 84, Geology 8, 1905.

month. Then during February there was a deficiency again in rainfall, and then the quake of the 28th, which was likewise followed by rain as in January. Just before the quake of the 28th, on the 26th, we had the lowest barometric pressure going over New England, recorded in two years, 28.96 inches at Boston. This low pressure area went northeastwardly and when it reached the Saguenay region, where there is a weak place in the crust, the crust gave way and we had the earthquake. It is true that the lowest pressure had passed on to the east before the shock came, but there is often a lagging effect in earth processes. In the opinion of the writer, the deficiency in rainfall and the very low pressure acting together was the straw that broke the camel's back.

At first thought it does not seem possible that a few inches of rainfall could affect the crust of the earth perceptibly, but when it is realized that the crust is so sensitive that seismographs can be used for predicting storm, which foretell their coming by a tilt in the ground great enough to swing the stylus connected with the pendulum in a direction opposite to that from which the storm is coming, it must be realized that the earth's crust is sensitive indeed. This tilting of the ground on the approach of a storm is due to the lowering of the air pressure over the storm center, which results in an extremely slight bulge in the ground over that area. When the barometer goes down one inch it means that .49 of a pound is taken off of each square inch of the earth's surface. This means that over each square mile in the area of lowest pressure before the quake of the 28th, the weight taken off the earth was over a million tons, so, as the area passed on northeastwardly, a great part of New England was relieved of a tremendous weight, and when the low pressure passed the weight came back again in higher pressure. So it is the alternate coming and going of low and high pressure areas that cause the stylus of the seismograph to swing slowly back and forth.

Now turning to the rainfall, the writer has calculated that the weight of eight inches of rain over all New England is a weight beyond comprehension. It is 38,260,224,000 tons. A deficiency of eight inches of rain, therefore, is equivalent to taking that same weight off New England. This, together with the abnormally low ground water, and last but not least the extremely low barometric pressure of February 26 to 28 over New England, might well be the set of circumstances which "set off" the shock of February 28. In making this calculation the area of New England was taken at 66,424 square miles, and the weight of one inch of rain for one square mile at 72,000 tons. No allowance was made for runoff and evaporation, so the above figure may be too high for the rainfall deficiency, but too low for the total deficiency of water, because the weight of the missing ground water could not be figured and included in the total, as it should be theoretically. To this figure of over thirty-eight billion tons must be added the much larger figure which would result from an estimate of the area affected by the drought in New York state and eastern Canada. Surely the addition of this area would triple the above calculation.

It may be objected that during other periods of low water and low barometric pressure we have had no quakes, but it must be remembered that a quake can not take place unless the strain is ripe enough for it, whatever the rainfall and barometric pressure may be. The shock would come without these aids eventually. The rainfall and low barometric pressure are looked upon merely as the finger that pulls the trigger. In a sinking area heavy rainfall and high barometric pressure would bring on the final shock, but here in New England, which is for the most part a rising area, it is reasonable to suppose that a low rainfall and low barometric pressure would be the deciding factors. In other words, rainfall and air pressure do not bring about the same results in the same way.

In 1912 Professor Noah Fields Drake,[2] then of Leland Stanford University, from a study of the remarkable earthquake records of China for the last 4,000 years, decided that it was plain that earthquakes vary with rainfall, there being more quakes with more rainfall. In 1913 the writer[3] found that, taking the earth as a whole, there seemed to be more quakes during rainy periods than during dry ones. In 1914 Dr. Stephen Taber[4] showed conclusively that in the region around Charleston, S. C., earthquakes and rainfall are related. In the area studied by Dr. Taber there has been an earthquake, on the average, every other month since the big Charleston earthquake of 1886. The results in the Charleston and Summerville area were so conclusive that it does not seem improbable that the great weight in rainfall, ground water and air pressure taken off of New England, New York and Quebec has played its part in the shocks of January 7 and February 28, notwithstanding the fact that a drought is concerned rather

[2] Drake, Noah Fields, "Destructive earthquakes in China," Bull. Seis. Soc. Amer., Vol. 2, No. 1, pp. 40–91, 1912.

[3] Sayles, R. W., "Earthquakes and rainfall," Bull. Seis. Amer., Vol. 3, No. 2, pp. 51–56, 1913.

[4] Taber, Stephen, "Seismic activity in the Atlantic coastal plain near Charleston, S. C.," Vol. 4, No. 3, pp. 108–160, 1914.

than high water. Visher[5] has recently given instances of the concurrence of tropical cyclones and earthquakes. The large number of cases of this kind makes it impossible to ignore low barometric pressures in the study of earthquakes. It is the rainfall factor which should receive more consideration.

ROBERT W. SAYLES

NOTE: Since writing the above observations, the Montana earthquake of June 27 has occurred. It is noteworthy that Montana has been suffering for some time from a deficiency of precipitation.

THE UNIVERSITY MUSEUM,
CAMBRIDGE, MASSACHUSETTS

ALLAN RIVERSTON McCULLOCH

THE news of the death in Honolulu of Mr. Allan Riverston McCulloch, curator of fishes in the Australian Museum and chief fishery expert of Australia, has lately reached his American friends and scientific associates. Mr. McCulloch was born in Sydney on June 20, 1855. For forty years he has been known as one of the leading naturalists in Australia, having particular charge of the fishes in the Australian Museum at Sydney. He is the author of numerous papers, the most important being "Deep Sea Explorations, of *The Woy Woy* (1907) and *The Endeavour* (1914, 1916, 1917)," and a descriptive record of the fishes of New South Wales (1914). With these were various papers descriptive of new forms in the Records of the Australian Museum. His work is throughout accurate, methodical and broad-minded, his interest extending beyond taxonomy to the general relations of fisheries. He kept for years a carefully arranged card catalogue of the fishes of the Pacific, and had planned a general descriptive work on the Australian species as well as a general list of the fishes of the Pacific.

Mr. McCulloch took part in several important exploring expeditions, having been with Sir Ernest Shackleton in some explorations, later with Frank Hurley in New Guinea, and still later on the great coral-bound Lord Howe Island. While in Lord Howe he had a severe illness and was granted by the museum a year's leave of absence for "recovering from mental breakdown." He came to Honolulu in July to attend a Fisheries Conference of the Pan-Pacific Union in September. The agenda for this conference he carefully prepared, and it has been accepted by his colleagues.

It is reported that while in Hawaii he had periods of exaltation followed by others of extreme depression, which seemed to indicate incipient loss of mind. Mr. Alexander Hume Ford, secretary of the Pan-Pacific Union, writes: "While a charming companion, he has been under a constant mental strain." While in this condition he shot himself, on September 6, at the age of seventy. He left behind a note saying "Something has gone wrong in my brain. I am afraid of madness. Therefore I am determined to end things." He explains the purchase of a revolver in order that no fault should be attributed to any associate.

McCulloch was a man of charming personality, with a good position, many friends and a record of worthy achievement. His further prospects were alluring. The only reason for his deed was a premonition of a wretched mental future, the beginning of which he had already felt.

DAVID STARR JORDAN

[5] Visher, Stephen, "Tropical cyclones and earthquakes," Bull. Seis. Soc. Amer., Vol. 14, No. 3, pp. 181–184, 1924.

SCIENTIFIC EVENTS

THE LONDON CELEBRATION OF THE BICENTENARY OF THE RUSSIAN ACADEMY OF SCIENCES

THE London *Times* states that the Society for Cultural Relations between the Peoples of the British Commonwealth and the Union of Socialist Soviet Republics held a meeting "on the initiative of the science section," in London on September 10 for the celebration of the bicentenary of the Russian Academy of Sciences.

Sir Richard Gregory, who presided, said they were assembled to carry out a suggestion made to the science section of the society that while there was being celebrated in Leningrad and Moscow the bicentenary of the Russian Academy of Sciences, those who were familiar with the scientific work and workers in Russia should assemble there in sympathy and congratulation on the attainment of the bicentenary. For two centuries the Academy of Sciences in Russia had kept alight the torch of learning, and although at times that torch might seem to have been flickering, it had never been extinguished. Speaking as an astronomer, so long as thirty years ago they in the astronomical world were astonished by some remarkable telescopic work carried out by the great Russian astronomer, Belopolsky. It might be news to some of those present to know that in continuation of that astronomical work there was being manufactured in this country at the present moment what would be the lens of the largest refracting telescope in the world to go to Russia. The largest at present was in the Yerkes Observatory in Chicago, which was 40 inches in diameter. The telescope now being constructed at the works of Sir Charles Parsons, in Newcastle, was

to be 41 inches in diameter. Whatever might be the differences between peoples, whether temporary or not, science, like art, literature or music, was international. They could not place any boundaries upon it. There could be no distinction between scientific work carried on in one part of the world or another as scientific work. The position of scientific workers as citizens was quite another matter. It was independent of the results achieved in scientific investigation. They were present purely in that spirit of intellectual cooperation between men working for the advancement of knowledge in Russia and in this country, and for no other reason but to offer, as it were, a message of strength and encouragement to those in Russia to carry on the work there.

Professor A. N. Kriloff, a member of the Russian Academy of Sciences; Professor P. I. Schmidt, curator of the Zoological Museum of the Russian Academy, and Mme. Z. Vengerova gave addresses on the work of the academy.

Sir A. Smith Woodward proposed:

> That this meeting of members and friends of the Society for Cultural Relations between the Peoples of the British Commonwealth and the Union of Socialist Soviet Republics sends cordial greetings and congratulations to scientific workers in the U.S.S.R., on the celebration of the bicentenary of the Russian Academy of Sciences, and in high appreciation of the great work by which the Academy has enriched the knowledge and culture of the world during the past two centuries, looks with confidence to the future for further contributions to promote the intellectual unity of mankind.

Dr. T. R. Parsons, of the University of Cambridge, seconded the resolution. He said he had recently visited some of the Russian scientific institutions, and any mention of Russian science would be incomplete without a reference to its physiology. The resolution was carried unanimously.

THE CONGRESS OF CLIMATOLOGY

DR. LEONARD HILL, of the National Institute for Medical Research, London, writes in the London *Times* that so successful was the Congress of Climatology just held at Davos that it has been decided to organize future congresses, one to be held in a different country every third year. Most distinguished scientific men have attended the recent congress, which has devoted itself to the study of climate and meteorology as applied to biology and preventive and curative medicine, but unfortunately the English and French members have been very few in number, and the English Foreign Office, by some oversight, failed to reply to the invitation to send an official representative, an invitation which was accepted by several other nations. The general secretary appointed for the organization of future congresses is Dr. Vogel-Eysern, of Davos, who has organized the recent one. The chairman of the organizing committee is Geh. Professor Abderhalden.

Davos offered three great centers of interest—first, the observatory of Dr. Dorno, famous for his application of the study of meteorology to biology and medicine; secondly, the new Swiss Institute under Professor Loewy for the study of physiology and tuberculosis treatment at high altitudes; and thirdly, the climatic conditions and sanatoria of Davos, famous for the treatment of tuberculosis. The proceedings of the congress, when published, will show the importance of the communications made to it in regard to meteorology, botany, physiology and hygiene and curative treatment.

THE SCIENCE NEWS CONFERENCE

A LUNCHEON-CONFERENCE was held at Southampton (England) on August 28 to discuss the advisability and feasibility of establishing a British Science News Service along the general lines of the existing American Science News Service. There were present at the conference: Professor J. H. Ashworth, University of Edinburgh; Sir John Biles, president of the Federation of Engineering Societies; Major A. G. Church, secretary of the National Union of Scientific Workers; E. N. Fallaize, secretary of the Royal Anthropological Institute; Sir Richard Gregory, editor of *Nature;* Dr. E. H. Griffiths, University of Cambridge, treasurer of the British Association for the Advancement of Science; Dr. A. C. Haddon, Christ's College, University of Cambridge; Sir A. Daniel Hall, director general of the intelligence department, Ministry of Agriculture; Professor Horace Lamb, president of the British Association for the Advancement of Science; Dr. P. Chalmers Mitchell, secretary of the Zoological Gardens and scientific editor of the London *Times;* Professor J. L. Myres, secretary of the British Association for the Advancement of Science; Sir Richard Paget, barrister, London; Joseph John Robinson, editor of the *Journal of the British Science Guild,* also a local newspaper in the provinces; Sir Arthur Schuster, past president of the British Association for the Advancement of Science; F. E. Smith, head of Admiralty research work; Professor D'Arcy W. Thompson, St. Andrews University; J. David Thompson, formerly director of the research information service of the American National Research Council; Dr. Vernon Kellogg, chairman of the executive committee, and Mr. Watson Davis, managing editor of the American Science Service.

President Lamb, of the British Association for the Advancement of Science, presided at the conference

and at his request Dr. Kellogg and Mr. Davis explained the organization and work of the American Science Service and Sir Richard Gregory opened a general discussion of the possibility and desirability of developing a similar British undertaking.

At the end of the discussion it was agreed that a later conference would be arranged to be attended by selected representatives of various British scientific bodies interested in the establishment of a Science News Service at which definite steps towards establishing such a service could be taken if it was agreed that such an undertaking was desirable. The general feeling as expressed at this first conference was that such an undertaking was both desirable and feasible.

OBSERVATIONS ON THE 1926 TOTAL SOLAR ECLIPSE

THE expedition sent by Swarthmore College from the Sproul Observatory to observe the total solar eclipse of January 14, 1926, plans to erect its instruments on the west coast of Sumatra in the vicinity of Benkoelen. The eclipse equipment was shipped from New York on the Dollar Steamship Liner *President Garfield* early in September and will reach Singapore on the third of November. The equipment will be reshipped from this port to Palembang, Sumatra, and then taken overland by rail and motor truck to its destination.

Totality occurs at Benkoelen about 2 hours 25 minutes P.M. local civil time, and lasts 3 minutes and 10 seconds. The altitude of the sun at mid-totality is approximately 52½ degrees.

The observers of the party are Professor John A. Miller (director of the expedition); Professor Ross W. Marriott, Dr. Dean B. McLaughlin, all of Sproul Observatory, Swarthmore College; Professor Heber D. Curtis, of Allegheny Observatory, University of Pittsburgh; and Mr. Adrian Rubel, Mr. Wilson M. Powell, Jr., and Mr. Lamont Dominick, of New York. In addition to the above observers, Mrs. John A Miller, Mrs. Heber D. Curtis, H. D. Curtis, Jr., and Mrs. Celia B. McLaughlin will accompany the expedition. Various members of the expedition have been leaving America since July, and it is expected that they all will reach Sumatra in time to get the erection of instruments under way by December 1.

Photographs of the corona will be made with cameras ranging in focal length from 30 inches to 62.5 feet. The largest of these cameras, which is of a stationary type, will have a lense 9 inches aperture mounted on a tower 50 feet high. This camera will be so constructed that it is directed to that point in the sky which marks the center of the sun at the time of mid-totality. The apparent motion of the sun will be counteracted by a moving plate holder driven by clockwork mechanism.

A large structural iron camera carrying twin lens 6¾ inches aperture and 15 feet focal length will be mounted equatorially in a heavy structural iron polar axis whose bearings rest on heavy concrete piers. This instrument is a powerful one, and with it it is planned to photograph the corona together with the star field surrounding the sun. The camera will be controlled by a large driving clock. It will have a guiding telescope mounted on it, and will be guided on the stars by means of slow motion screws. It is further planned to make photographs with this camera in an attempt to find out whether there is any deflection of light caused by refraction due to the passage of light rays through the cooling atmosphere of the shadow cone.

Two large concave gratings will be mounted to photograph the flash spectrum. One of the gratings has coarse rulings and is of short focal length—Professor Curtis will use this to continue his work in the infra-red part of the spectrum. The other grating is ruled 20,000 lines to the inch and has a radius of curvature of 15 feet. This will be used to photograph that visual part of the spectrum between 4,500 Å and 6,500 Å.

Two etalon interferometers will be used in an attempt to detect motion in the corona. The instruments have different plate separations, but both are designed for the green coronium line $\lambda = 5{,}303$. Each instrument is fitted with an objective prism and a color screen to weaken the background for the interference fringes.

In addition to the above instruments a one prism slit spectrograph will be used to photograph the *Fraunhofer* lines in the corona, and an objective prism spectrograph will be mounted to search for gas clouds in the corona. Mr. Wilson Powell, Jr., will make color photographs of the corona during totality. Moving pictures will be made during the partial and total phases of the eclipse.

ROSS W. MARRIOTT

SCIENTIFIC NOTES AND NEWS

PROFESSOR EDWARD DE MILLE CAMPBELL, professor of chemistry and metallurgy at the University of Michigan, died on September 18, aged sixty-two years.

HENRY C. LORD, professor of astronomy and since 1895 director of the observatory at the Ohio State University, died on September 15, at the age of fifty-nine years.

AT the opening sessions of the meeting of the Roentgen Ray Society in Washington on September

22, the award of the Charles Lester Leonard prizes for meritorious service performed during the year in X-ray work was made to Dr. Evarts A. Graham, of St. Louis, Mo., and to Dr. G. Failla, of New York City.

THE French government has made Professor Casimir Cépède, head of the department of applied biology at the University of Paris, a chevalier of the Legion d'Honneur. M. Sebileau, professor of anatomy, University of Paris; M. Jean André, professor of chemistry, Institute of Agronomy, Paris; M. Phillipe Glangeaud, professor of geology, University of Clermont, and M. Sartory, professor of pharmacy, University of Strasbourg, have been promoted to officers of the legion.

DR. LEOPOLD SPIEGEL, the well-known chemist of Berlin, has celebrated his sixtieth birthday.

PROFESSOR J. C. HINTON, of the Wesleyan College, Macon, Ga., has retired after thirty-five years of service. He has been dean of the college for the past twenty-five years.

IT is announced that Dr. Harvey J. Howard, of the Rockefeller Hospital, Peking, who was kidnapped by Chinese bandits in July, has been freed.

G. A. BOLE, superintendent of the Ceramic Experiment Station of the Bureau of Mines, Columbus, Ohio, has been designated as supervising ceramist of the bureau and as such will have technical supervision of all ceramic investigations carried on both at the Columbus station and at the other experiment or field stations.

CLIFTON E. HALSTEAD, formerly of Syracuse University, has resigned to accept a position with E. R. Squibb & Sons, New York City.

THE vacancy caused by the death of W. E. Cutler, leader of the British Museum East Africa Expedition, has been filled by the appointment as his successor of Frederick W. H. Migeod.

SIR FRANK HEATH, secretary to the British Department of Scientific and Industrial Research, will shortly visit Australia.

DR. H. BERKELBACH VAN DER SPRENKEL, assistant professor of anatomy, University of Utrecht, and Dr. John Cairney, lecturer in anatomy in the University of Otago, Dunedin, New Zealand, are spending the current academic year at the department of anatomy in the University of Chicago as Rockefeller fellows, engaged in research upon the comparative anatomy of the nervous system.

DR. A. E. JENKS, professor of anthropology, University of Minnesota, has taken up residence again at Minnesota after two years of absence—the first with the National Research Council, Washington, the second in travel and study in Europe. In addition to the regular 1925 summer session courses of the University of California (southern branch, Los Angeles), Dr. Jenks gave a course of four weekly public addresses under the title, "Known facts about prehistoric man in Europe," as follows: (1) Fossil man, (2) Influence of environment and animal companions, (3) Material culture, and (4) Non-material culture.

DR. ALEŠ HRDLIČKA, of the Smithsonian Institution, has reached Cape Town, South Africa, from Adelaide, Australia, on his return to Washington.

DR. WM. A. PERLZWEIG, of the Johns Hopkins Medical School, is spending three months at the Carlsberg Institute in Copenhagen.

DR. CHARLES C. MOOK and Coleman S. Williams, of the American Museum of Natural History, have returned to New York with many fossil specimens gathered in a three months' tour through western Montana and Idaho.

THE first lecture of the Harvey Society, under the patronage of the New York Academy of Medicine for the season 1925–1926, will be given on October 3 by Dr. F. R. Nager, professor of otology at the University of Zurich, Switzerland, on "New problems in otology."

DR. HORATIO B. WILLIAMS, Dalton professor of physiology in the College of Physicians and Surgeons, Columbia University, was the principal speaker at the opening exercises at the medical school on September 24. His subject was "The future of biological investigation."

DR. G. H. MATTHEWS, of the Eastman Kodak Research Laboratory, will speak on "Recent developments in color photography" before the Western New York Section of the American Chemical Society and the Niagara Falls Section of the American Electrochemical Society, which will meet jointly on October 20 in Buffalo, N. Y.

PROFESSOR E. GLEY, Paris, was tendered a banquet by the dean of the medical faculty and others on his visit to Havana on his way to lecture in Mexico. He spoke at Havana on "The influence of the thyroid on growth" and "The origin and action of epinephrin." He is to deliver a series of eight lectures on his return visit.

PROFESSOR G. BERTRAND, of the Pasteur Institute, Paris, has been invited by the Instituto de la Universidad de Paris, at Buenos Aires, to deliver a course of lectures on biochemistry, with especial reference to agriculture.

DR. EPHRAIM MACDONALD EWING, formerly assistant professor of physiology at the Tulane University of Louisiana School of Medicine, died on August 27, aged thirty-seven years.

JOHN MURDOCH, naturalist and ethnologist, and formerly librarian at the Smithsonian Institution, died on September 22, aged seventy-three years.

ON September 11, Professor Ernst von Hammer, of the Technische Hochschule of Stuttgart, Germany, died at the age of sixty-seven years. For over forty years he had filled the chair of geodesy and practical astronomy in that institution and he was the author of numerous books and articles on subjects connected with his work.

PROFESSOR GEORG KLIEN, director for more than forty years of the East Prussian Agricultural Institute in Königsberg, has died, aged seventy-six years.

THE United States Civil Service Commission has announced an open competitive examination for junior sanitary engineer, at a salary of $1,860, applications for which will close October 24. The duties are to carry on public health work involving engineering problems, including stream pollution, sanitary surveys, treatment of water, sewage and industrial wastes, drainage and anti-malarial measures, and other similar matters.

APPOINTMENTS to the staff of the Wilmer Eye Institute at Johns Hopkins University Medical School, Baltimore, have been announced as follows: Dr. William Holland Wilmer, director; Dr. Cecil H. Bagley, resident ophthalmologist and instructor in ophthalmology; Drs. Leo J. Goldbach, Alan C. Woods and Clyde A. Clapp, associates in clinical ophthalmology; Drs. Reginald D. West and Dobert Y. Fechtig, instructors in clinical ophthalmology; Drs. R. S. Wygodski, Bernard V. Kelly, Joseph E. Brumbach, Joseph G. O'Brien, Aaron Robinson, Franklin Hazelhurst, Jr., Chester E. Hurwitz, Frank A. Pacienza and Frederick A. Holden, assistants in clinical ophthalmology. Charles L. Burky will do research work. Those who will devote full time to the institute (having no private practice) are Drs. Wilmer, Bagley and Wygodski. The institute opened on October 1, with sixty beds in the Nurses' Home Building of the Johns Hopkins Hospital group; this adjoins the administration building.

A ONE-WEEK'S course in elementary and advanced chemistry was given in connection with the Exposition of Chemical Industries, held in Grand Central Palace during the week of September 20 to October 3. Daily addresses were given by Drs. Arthur D. Little, H. E. Howe, William Haynes and Charles H. Herty.

WE learn from *Nature* that the opening meetings of the fifth congress of the French Society of Chemical Industry will be held at Paris in the second week in October. As part of the proceedings, a special assembly will commemorate, on October 11, the one hundredth anniversary of the practical establishment of the soap industry by the French chemist, Michel Eugène Chevreul, who, in 1825, with J. L. Gay-Lussac, started a factory for the manufacture of stearic acid. Through his prolonged scientific researches Chevreul explained the process of saponification. The president of the French Republic, members of the Academy of Sciences and those of kindred bodies will join in the forthcoming commemorative session. Born at Angers on August 31, 1786, Chevreul died in 1889, at the age of one hundred and three years. At seventeen he went to Paris, entering Vauquelin's chemical manufactory; ultimately he became director there of the laboratory. Later (1824) he took up the post of director of the dyeing department and professor of dyeing at the tapestry works of the Gobelins. His researches on the principles of harmony and contrast of colors were carried out at this period. In 1864 Chevreul was appointed director of the Museum of the Jardin des Plantes, retiring in 1879. Elected a foreign member of the Royal Society in 1826, Chevreul was awarded the Copley Medal in 1857. The centenary of the birth of this distinguished chemist was celebrated in Paris with signal honor and many felicitous demonstrations.

THE third International Aerial Navigation Congress will meet in Brussels from October 6 to 10, under the patronage of King Albert and Prince Leopold. This congress, which follows that of Paris in 1921 and of London in 1923, will be divided into six sections—juridical, medical, scientific, air navigation, technical, and travel and propaganda.

THE New England intercollegiate geological excursion will be held on October 9 and 10 in the vicinity of Waterville, Maine. New fossiliferous localities and the glacial geology of that region will be studied. Those desiring to attend should communicate with Professor E. H. Perkins, Colby College, Waterville, Maine.

THE Connecticut Agricultural Experiment Station will celebrate its semi-centennial on October 12. Connecticut was the first state to establish an agricultural experiment station, thus inaugurating the movement in this country.

THE first of the radio talks of the Smithsonian Institution for the season, entitled "Flies," by Dr. J. M. Aldrich, was given from Station WRC on October 1, and the institution will present a talk on each Thursday evening following. During the summer, arrange-

ments were made for a similar series of talks originating in New England to be given from Westinghouse Stations WBZ at Springfield, Mass., and WBZA at Boston under the auspices of the Burgess Radio Nature League in cooperation with the Smithsonian Institution.

THE American Medical Association is to publish a journal on pathology to be known as the *Archives of Pathology and Laboratory Medicine*, beginning with January, 1926. The editorial board for this new journal has not been made public.

MORE than 4,000 specimens of the minerals of rarer metals gathered by Frank L. Hess, during eighteen years' service with the U. S. Geological Survey, have been turned over to the U. S. National Museum. These specimens will form an important addition to the collection.

THE late Miss Lilian Suzette Gibbs, of Teneriffe, Wales, a well-known botanist, has left to the trustees of the British Museum (Natural History Botanical Department) her collections of plants and books and papers connected therewith, and to the University of London such a sum as will produce a net annual income of £150 for a studentship in cancer research, either on the physiological or the chemical side, to be called "The Laura de Saliceto Studentship" in memory of her mother.

THE *Riforma Medica* states that the Argentine government has donated 10,000 liras to the Grassi Institute at Rome for study of parasitic diseases.

AT Yale University funds have been provided for the promotion of two pieces of research in the school of medicine. A grant from the Henry B. Loomis Fund will be used by Dr. Dudley J. Morton, instructor in surgery, for an investigation of the mechanics of the human foot and its disorders, and a gift of $5,000 from Mrs. Philip J. Goodhart and her son, Howard L. Goodhart, Yale, '05, of New York City, provides for the further investigation of a scarlet fever antitoxin by Dr. Francis G. Blake, chairman of the department of internal medicine.

THE governing board of the University of Michigan has recently accepted the management of the Menominee County Agricultural School, located at Menominee in the Upper Peninsula. It is the plan of the board to continue the present course of study, which is of a secondary type, and to add such other courses in agriculture and home economics as will extend the service of the institution to that portion of the state. For the next two years $75,000 has been appropriated by the state to operate the school. Karl Knaus, formerly county agent leader in Kansas, has been appointed superintendent.

UNIVERSITY AND EDUCATIONAL NOTES

ASA CANDLER has made an additional gift of $300,000 to Emory University, Atlanta, Ga., bringing the total amount of his gifts to the institution up to $7,000,000.

THE University of Wisconsin has decided to lengthen its course in pharmacy from two to three years. This is in conformity with the recommendation of the American Conference of Pharmaceutical Faculties, in which thirty-four leading universities hold membership.

HENRY O. LINEBERGER, president of the North Carolina State Dental Society, is chairman of a committee of five dentists, comprising S. J. Betts, Hillsboro; Isaac H. Davis, Oxford; G. L. Hooper, Duke; J. H. Judd, Fayetteville, designated by the dental profession to endeavor to secure the erection and maintenance of a first-class college of dental medicine and surgery in North Carolina.

PROFESSOR W. O. HOTCHKISS, state geologist of Wisconsin, has announced his acceptance of the presidency of the Michigan School of Mines at Houghton, Mich.

DR. JOHN W. BURKE has been appointed professor of ophthalmology in the Georgetown University Medical School to succeed Dr. William H. Wilmer, who recently went to the Johns Hopkins Medical School.

PROFESSOR FREDERICK WOOD, of Lake Forest College, has been appointed professor of mathematics at Wesleyan College, Macon, Ga.

C. C. HAMILTON, associate entomologist at the University of Maryland, has been appointed associate professor of entomology at Rutgers University.

DR. W. H. PYLE, of the University of Missouri, has gone to Teachers' College, Detroit, to carry on research and teaching on the psychology of learning.

CHAS. W. RODEWALD, formerly an instructor in the department of chemistry at the University of Nebraska, has been appointed assistant professor of chemistry at Washington University, St. Louis.

DR. WILLIAM W. GRAVES, for a number of years chairman of the department of neurology at the St. Louis University School of Medicine, has been appointed director of the department; Drs. Louis Rassieur and Max W. Myer have been advanced from the rank of associate professors of surgery to professors of surgery.

DR. PERCY BRIGL, first assistant in the institute of

physiological chemistry at the University of Tübingen, has been appointed professor and director of the institute of agricultural chemistry at the Agricultural High School at Hohenheim.

DR. FELIX HAFFNER, of Munich, has been appointed professor of pharmacology at the University of Königsberg to take the place of Professor H. Wieland, who has retired.

DISCUSSION AND CORRESPONDENCE

SOLAR VARIATION AND THE WEATHER

IN the New York *Times'* issue of July 26, Dr. McAdie, director of Blue Hill Meteorological Observatory, reviews three papers by Messrs. Clayton, Hoxmark and Abbot recently published by the Smithsonian Institution. Like many others, for instance, Floyd W. Parsons in the *Saturday Evening Post* of July 25, Dr. McAdie appears to understand that persons connected with the Smithsonian Institution have predicted cool or disastrous summers for 1925, 1926 and 1927.

This is not the case. No person connected in any way with the Smithsonian has ventured any such excessively long-range forecasts or knows of any method of making them. This mistake arises from confusing with us Mr. Herbert Janvrin Browne and perhaps others who have no connection at all with the Smithsonian Institution, though they claim to make use of some of our results. We disclaim all responsibility for their forecasts.

The story we told in the three articles referred to was mainly twice told, once by their texts, and again by their illustrations, but yet Dr. McAdie does not appear to have grasped it. Certainly he has not clarified it for his readers, and therefore I venture to do so. Perhaps Dr. McAdie, as they say, failed to see the forest because it was obscured by the trees.

What we told is essentially this: Measurements by the Smithsonian Institution of the sun's rays available to warm the earth have been going on for twenty years. Since 1918 they have been made on every possible day at our Chile observatory, and since 1920 have also been made at our Arizona observatory. Prior to that, and from their inauguration in 1905, they were made, during part of the year only, at Mount Wilson, California. The duplicate daily results since 1920 agree within one half per cent., and combine to indicate decided variability of the sun.

Some authorities still doubt the adequacy of our proof of the sun's variability. In the paper by Abbot, their objections are discussed, and many confirmatory evidences tending to support the view of the variability of the sun are given.

If the sun varies, the earth's weather ought to vary, too. Mr. Clayton has examined this question for more than ten years, first while official forecaster of Argentina, and since 1923 privately, with financial support by Mr. John A. Roebling, and working in cooperation with the Smithsonian Institution.

As early as 1917, Clayton appeared to find definite relations between the solar changes reported by the Smithsonian Institution and weather changes in all parts of the world. He reduced these relations to a system of weekly forecasting which was adopted officially in Argentina in December, 1918, and is still used there.

Hoxmark, who succeeded Clayton as Argentine official forecaster, gives in his paper the degree of success in making definite forecasts of temperature and rainfall for Buenos Aires each week since he assumed charge in 1922. He employs the much-used mathematical method of correlations in comparing the predictions with the events, because it is independent of personal bias. One does not see why Dr. McAdie should make fun of so sensible a procedure. The Argentine official weekly forecasts, while by no means perfect, are in the right direction by far the most of the time, and are *sold*, not given away, to satisfied customers.

Clayton's paper reports his recent studies of the weather of the United States in its relations to the apparent solar changes. Having found clear evidences of many such relations, he has reduced his results to a system of forecasting of temperatures for the city of New York. To make a rigid test, he had, for over a year, forwarded daily to the Smithsonian Institution definite forecasts of daily New York temperatures three, four and five days in advance, average weekly temperature departures forecasted two days before the beginning of each week, and average monthly temperature departures forecasted two days before the beginning of each month.

The Smithsonian Institution has compared these forecasts with the events for a period exceeding one year, and finds by mathematical methods, altogether without opportunity for personal bias, that a real foreknowledge by Mr. Clayton is exhibited.

It is true that the correlations are not high. The relations between solar variation and the weather are highly complicated. Much more work and study are required to make them clearer. Moreover, the accuracy and fullness of the solar data are still not adequate to the purpose. Fortunately the National Geographic Society has recently financed the installation of a third solar observatory to be located in the eastern hemisphere and to cooperate with the two in Chile and Arizona. If further studies by Clayton and others seem to warrant going on with this new departure in weather forecasting, it is to be hoped

that funds may come from some source to set up still a fourth solar station.

The Smithsonian Institution has no intention of making public forecasts. That is the province of the Weather Bureau. But it is hard to see why an honest effort to test the value of hitherto unused data for forecasting purposes should receive anything but kindness from meteorologists.

Yours faithfully,

C. G. ABBOT,
Acting Secretary

SMITHSONIAN INSTITUTION
SEPTEMBER 1, 1925

TERTIARY GLACIATION IN WYOMING, COLORADO AND UTAH[1]

SINCE 1914 the origin of erratic boulders up to twenty feet long on Green Mountain and elsewhere in Central Wyoming, at altitudes of about 8,500 feet, had been an unsolved problem until June, 1925, when definite evidence was found of glacial deposits of mid-Tertiary age. A fresh grade on the state highway five miles west of Alcova, Wyoming, exposed good glacial débris with boulders exhibiting excellent striations and scoured faces. This débris definitely occurs beneath the White River formation, classed as Oligocene. Elsewhere in the Sweetwater Valley the glacial boulders rest on Eocene formations.

The glacier leaving these big erratic rocks originated on the Wind River Mountains and extended at least 125 miles toward Casper.

Definite glacial débris nearly 1,000 feet thick on Diamond Peak, Colorado, and Uinta quartzite boulders twenty feet long, showing grooved flat faces, on Aspen Mountain, Wyoming, prove the glacial origin of the Bishop conglomerate, which is older than the Brown's Park and younger than the Green River formations. The Bishop occurs all around the Uinta Mountains.

The smoothed outcrops of the pre-Cambrian granite near Encampment, Wyoming, and boulder beds beneath the North Park formation at Walcott indicate mid-Tertiary glaciation off the Medicine Bow Range.

Large boulders with peculiarly flattened faces, as if ice-scoured, at the bottom of the Castle Rock conglomerate and on Green Mountain are thought to be traces of the same glacial epoch in the Denver Basin.

The possibility of the Kingsbury conglomerate and other singular boulder deposits in the Rocky Mountains being a phase of this glaciation is recognized, which when carefully studied will perhaps prove extensions of the discovery of an important epoch of glaciation in post-Eocene and pre-Miocene time, and if certain beds are Oligocene, then it is also pre-Oligocene.

C. J. HARES
CASPER, WYOMING

[1] Preliminary communication.

AN OBVIOUS NEW CASE OF POLYEMBRYONY

MORPHOLOGISTS in general are so greatly interested in polyembryony that all new cases should be advertised.

In the August, 1925, number of the *Journal of Economic Entomology*, Mr. S. J. Snow, of the Bureau of Entomology, in an article entitled "Observations on the cutworm, *Euxoa auxiliaris* Grote, and its principal parasites," records the rearing of an encyrtid parasite of this cutworm which is, very obviously, polyembryonic, since from 1,068 to 1,511 individuals were reared from a single cutworm.

The species is *Berecyntus bakeri* Howard. The observation is not surprising, since this parasite is related to the Copidosoma originally studied by Marchal, although it has a very different *facies*.

Incidentally, attention should be called to J. Waterston's paper entitled "A new polyembryonic encyrtid, *Copidosoma tortricis*, a parasite of *Tortrix comariana*," published in the *Annals of Applied Biology* for September, 1922.

L. O. HOWARD
U. S. DEPARTMENT OF AGRICULTURE

THE "HARMLESS" CORAL SNAKE

ERROR as well as truth has the faculty of repeated rising after frequent crushing. Certain misinformation has such capacity for harm that the task of the cynic becomes indistinguishable from that of the philanthropist and at the reappearance of the hoary falsehood of the harmless coral snake it becomes meet, right and our bounden duty to do all that in us lies to blast it as publicly as possible.

Some twenty-five years ago Kipling wrote "Rhinegelder and the German Flag," a story of a collector in Venezuela who, misled by the published statement of an American authority, thought nothing of being bitten by a coral snake and so died. His last bitter words as he felt his arm and realized his position might serve as a text. "It is genumben to der clavicle. I am a dead man, and Yates he haf lied in print."

In Newman's recent "Vertebrate Zoology," on page 257, there is the following statement: "The coral snakes are said to be extremely poisonous, but their biting apparatus is so constructed that they can not open the mouth wide enough to bite a human being so that they may be set aside as harmless, so far as man is concerned."

The facts are as follows. Even newborn snakes can open their mouths wide enough to bite a man's finger and the theory that a grown coral snake can not bite a man is *a priori* ridiculous, even setting aside recorded instances of their so doing. Willson (Archives Int. Med., 1908, 1, p. 516) has collected records of 740 cases of snake bite in the United States. The harmless coral snake, unable to bite a human being, actually bit eight human beings, of whom six died, making a mortality of 75 per cent., as against 408 cases of rattlesnake bite, of whom forty-eight died, a mortality of under 12 per cent. The coral snake is therefore over six times as deadly as a rattlesnake, and, while they seldom bite people on account of small size and secretive nature, yet they are potentially the most deadly animals in the Americas.

E. R. DUNN

SMITH COLLEGE

SCIENTIFIC BOOKS

Anatomy and Physiology of the Honeybee. By R. E. SNODGRASS, Bureau of Entomology, first edition, xvi + 326 pp., 109 figs. New York: McGraw-Hill Book Company, 1925.

IN 1910 Snodgrass prepared for the Bureau of Entomology a bulletin (Tech. ser. 18, 162 pp., 57 figs.) entitled "The anatomy of the honeybee." The edition of this bulletin was limited by the restrictions unfortunately placed on certain departmental publications solely because of their size, and the supply was soon exhausted. Since that time there has been a limited but constant demand for copies of this bulletin, which could not be supplied, and finally the author was induced to rewrite and enlarge the portion on anatomy, to include the results of the more recent investigations on the functions of the various organs and to issue the result in book form. The present work is the result. While it is designated a first edition, it is actually an outgrowth and enlargement of the earlier bulletin.

In this book the number of figures is doubled and the text is approximately twice the size of that of the bulletin. Most of the figures formerly used, many of which contain several drawings, have been retained and many new and original drawings now appear. An extensive bibliography is appended, listing especially the more important papers in this field published within the past decade, but noticeably omitting some older works which have served to confuse rather than to advance our knowledge of the anatomy and physiology of the honeybee. Developmental stages are included, based chiefly on the work of Nelson, who worked in the same laboratory. Other investigations of the bee culture laboratory of the bureau form an important part of the new material.

Morphology is no longer a phase of biological investigation to which most workers are attracted, yet it will be admitted that a sound knowledge of structure is essential as a foundation to satisfactory and reliable work in physiology and behavior. The author of this book has rendered a real service in presenting a comprehensive and thoroughly dependable manual of honeybee anatomy. The anatomy of almost no other animal aside from man himself has been the subject of more books and papers than has that of the honeybee, yet unfortunately many and perhaps most of the previous authors in this field have lacked a knowledge of comparative anatomy of insects and as a result have in too many cases given fanciful interpretations and incongruous names to the things recorded as observed. It is therefore a pleasure to welcome a book which does scientific justice to its subject and which is based on a well-grounded knowledge of comparative anatomy. This method of approach, as the author points out, "makes acquaintance with the bee in the end not only easier but more interesting, since to a knowledge of facts it adds understanding."

In this book, however, the bee is a living thing. The short life of the honeybee and its specialized colonial life make physiological experimentation difficult, so that a considerable amount of our knowledge of its physiological processes have been derived by deduction from studies of morphology and by analogy from studies of allied species. The physiological processes of insects have in too many cases not been thoroughly investigated, but in so far as this has been done for the honeybee and allied species, the author has included a comprehensive account of the investigations of others and has included certain new investigations of his own. His work on the so-called fat body is especially interesting. Most of the physiological work mentioned has been done within the past decade. In so far as investigations would warrant, there is a discussion of the cytology of parthenogenesis and inheritance in the honeybee. The work on the structure and functions of the sense organs is especially well done, and the author has corrected certain errors in morphology which have appeared in earlier work on these organs. Various phases of the behavior of the bee are discussed, where the behavior centers about certain organs, although a discussion of bee behavior is not part of the plan of the book. It is needless to itemize the various subjects discussed aside from stating that they are just what one expects in a book with this title.

The important facts to record concerning this book pertain primarily to the qualifications of the author

for an undertaking of this character, since he combines several abilities which especially fit him for such a task. He is undoubtedly the most skilled artist who devotes his artistic abilities to insect morphology. He has had wide experience in morphological investigations and possesses a broad knowledge of the comparative anatomy of insects, and as an insect morphologist has no superior. He also possesses a rare ability to write in an attractive style, one which holds his readers to an unusual degree. To possess artistic skill, knowledge of comparative anatomy and a facility in the use of one's own language is indeed a rare combination, and because of these qualifications the author has presented a book which no student of insects can neglect and one which raises the standards of work in insect morphology and physiology.

To those especially interested in the honeybee, this book is a treasure, for it will serve as a starting point for much future work in bee behavior and physiology, as well as in practical beekeeping. It gives under one cover a fund of scientific knowledge of this most interesting but too often misrepresented insect and will help to dim the luster of the pseudo-scientists who have so long encumbered bee literature with their speculations. From all these different points of view, this is a notable book which deserves hearty commendation.

E. F. PHILLIPS

CORNELL UNIVERSITY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN INEXPENSIVE AIR PRESSURE INJECTION APPARATUS

AIR pressure apparatus for embalming and injecting has many advantages over that depending on gravity, but most biological laboratories are not equipped with compressed air and electrically operated systems are expensive to install. The equipment described here is only a simple adaptation of a contrivance common in chemical laboratories, but several months' use in preparing a wide variety of dissection material has convinced the writer of its utility. Furthermore, it is very inexpensive.

The air pump is a common filter pump, *g*, fig. 1, whose outlet is passed through the stopper of an aspirator bottle, *A*, of four liters capacity or greater. Air and water are discharged together into the bottle. The water escapes through the lower outlet, while the air is led through bottle *B* to *C*, which contains the liquid to be injected.

To operate: Open pinchcocks *a*, *c* and *d* and close

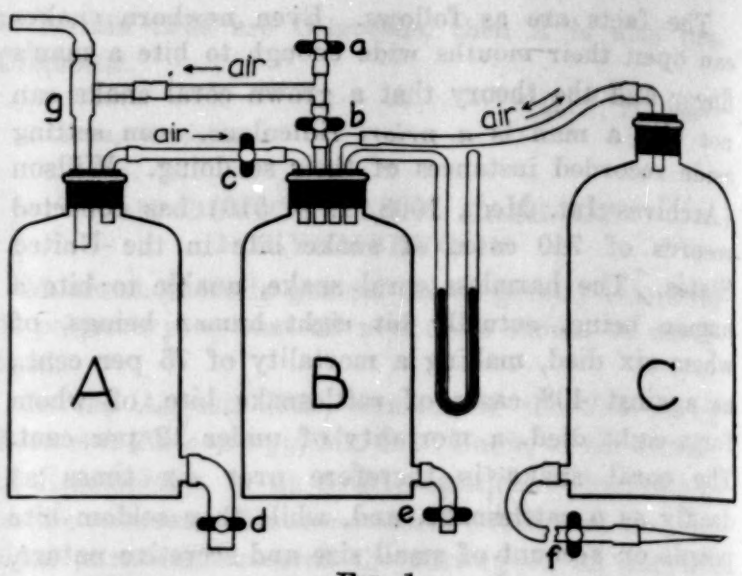

FIG. 1

b, *e* and *f*. Turn on the water. Partially close *d* and so adjust it that the desired pressure is maintained, with air and water escaping through *d*. The flow of liquid through the canula is then controlled at *f*. Always open *d* to release the pressure before turning off the water.

To fill *C* with injection fluid: Close *a* and *c*, open *b* and turn on the water. This will reduce the pressure in *C* and it can then be filled through the tube which holds the canula without the necessity of moving the bottle or of pouring the liquid through a funnel.

The bottle, *B*, is necessary unless *A* is quite large, because *A* will sometimes fill up with water and *B* then helps to keep it out of the air tubes and out of *C*. If *A* is large, *B* can be replaced by a T-tube and the manometer inserted at any convenient point. The manometer is necessary in order that the operator may always know and control the pressure with which he is working. The type shown, with the outer end sealed, will give the least trouble. Stoppers must be wired in and the ends of glass tubing should be beaded to hold the rubber tubing securely.

The apparatus as shown should not cost over fifteen dollars. If aspirator bottles are not available, a tube inserted through the stopper nearly to the bottom will serve for the lower outlet. Some manufacturers supply as a unit, made of metal, the equivalent of the filter pump and bottle *A* with the inlets and outlets fitted with stopcocks. This is listed as *blast apparatus* or *filter pump apparatus, Muesche.*

The outfit used by the writer consists of one of these units, a one liter wide-mouth bottle (*B*), and (*C*) two carboys and two four-liter bottles. The carboys were set outside the window in the light well and are never touched since they can be filled from the work table. The two bottles have long air tubes and can be moved about. They are used for small quan-

tities of fluid and for starch mass which must be prevented from setting. This equipment, with the moderate water pressure available, will develop an air pressure of ten pounds, though two to five are all that are usually needed. It will deliver one liter of air per minute at five pounds pressure and over four liters at atmospheric pressure. It will maintain an even pressure without attention unless the air is suddenly released or the water pressure varies. This apparatus, in comparison with the gravity apparatus formerly used, saves time and necessitates less handling of unpleasant fluids and less moving of heavy bottles.

The same equipment can also be used for operating a small blast burner, for stirring with air, for aerating aquaria, etc. It is especially useful for salt water aquaria where running sea water is not available. Fresh air may be secured from out of doors by running a tube to the pump from any desired point, and the air delivered to the aquarium is washed, cooled and moistened. The writer has aerated fourteen aquaria at one time with one pump. The tube to each aquarium must be provided with a clamp to regulate the flow of air and to maintain some pressure in the system. Especial care must be taken that water from the pump does not get through the air line into the aquaria.

EDGAR L. LAZIER

REED COLLEGE

SPECIAL ARTICLES

CERTAIN OXIDES OF IRON IN SOME NEW CATALYTIC ACTIONS[1]

IN current numbers of the *Philosophical Magazine* and the *Journal of Biological Chemistry* detailed accounts of our work with synthetic iron oxides and their use in catalyzing certain reactions of biological interest will be presented. The results appear to be of sufficient general interest to justify a brief description in this journal.

The oxide with which we start is the magnetite which is formed when a solution containing one mol of ferrous sulphate and two mols of ferric sulphate is poured into a boiling solution of sodium hydroxide of sufficient strength to remain alkaline after the addition of the sulphates. The black, micro-crystalline precipitate is washed to remove the sulphate, and it is then filtered off and dried. Two distinct ferric oxides can be derived from this magnetite. One, which we call "oxidized magnetite," is obtained by oxidation of the magnetite in a stream of oxygen at a low temperature of say, 300° C. The oxidized magnetite is ferric oxide of the composition Fe_2O_3 but it retains the ferro-magnetic properties of the magnetite Fe_3O_4, with which we started, and it retains also the original cubic crystal structure. If, now, the oxidized magnetite, which is completely oxidized to Fe_2O_3, is heated to 550° C. or more, it loses its ferro-magnetic properties, and the crystal unit takes on the rhombohedral form usually found in hematite, Fe_2O_3. This transformation of oxidized magnetite into hematite is non-reversible, for the oxide remains permanently non-magnetic and the structure does not change back to cubic when the oxide cools. These physical properties of the magnetite with which we begin, of the oxidized magnetite, and of the hematite are compared in the first three rows of Table I.

TABLE I

	Fe_3O_4 (Magnetite)	Active Fe_2O_3. Fe_3O_4 oxidized at 330° C. (Oxidized magnetite)	Inactive Fe_2O_3. Fe_3O_4 oxidized at 330° C., then heated to 550° C. (Hematite)
Prussian blue test for ferrous iron	+	—	—
Maximum magnetic susceptibility, k.	0.152	0.182	0.0036
Crystal unit	cubic	cubic	rhombohedral
Absorption of water, average per cent.	27	27	21
Blood test. Oxidation of benzidine by H_2O_2 in presence of ——	good	good	none
Growth of *B. lepisepticum* in broth and in presence of ——	good	good	none
Absorption of oxygen, average initial rate, $\frac{Cm^3}{gr.\ hr.}$	0.0044	0.0080	0

The table brings out the marked tendency to absorb water which is characteristic of the oxides if prepared in the way we have described. The table shows, too, that the appearance of ferro-magnetism in an oxide

[1] From the Laboratories of the Rockefeller Institute for Medical Research, New York.